Aegis Combat System Interoperability - Designing, Building and Testing

Orlando Carvalho

LOCKHEED MARTIN
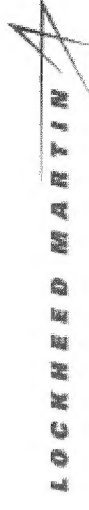
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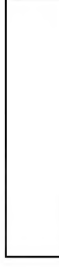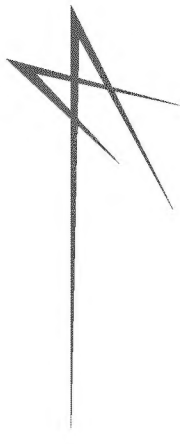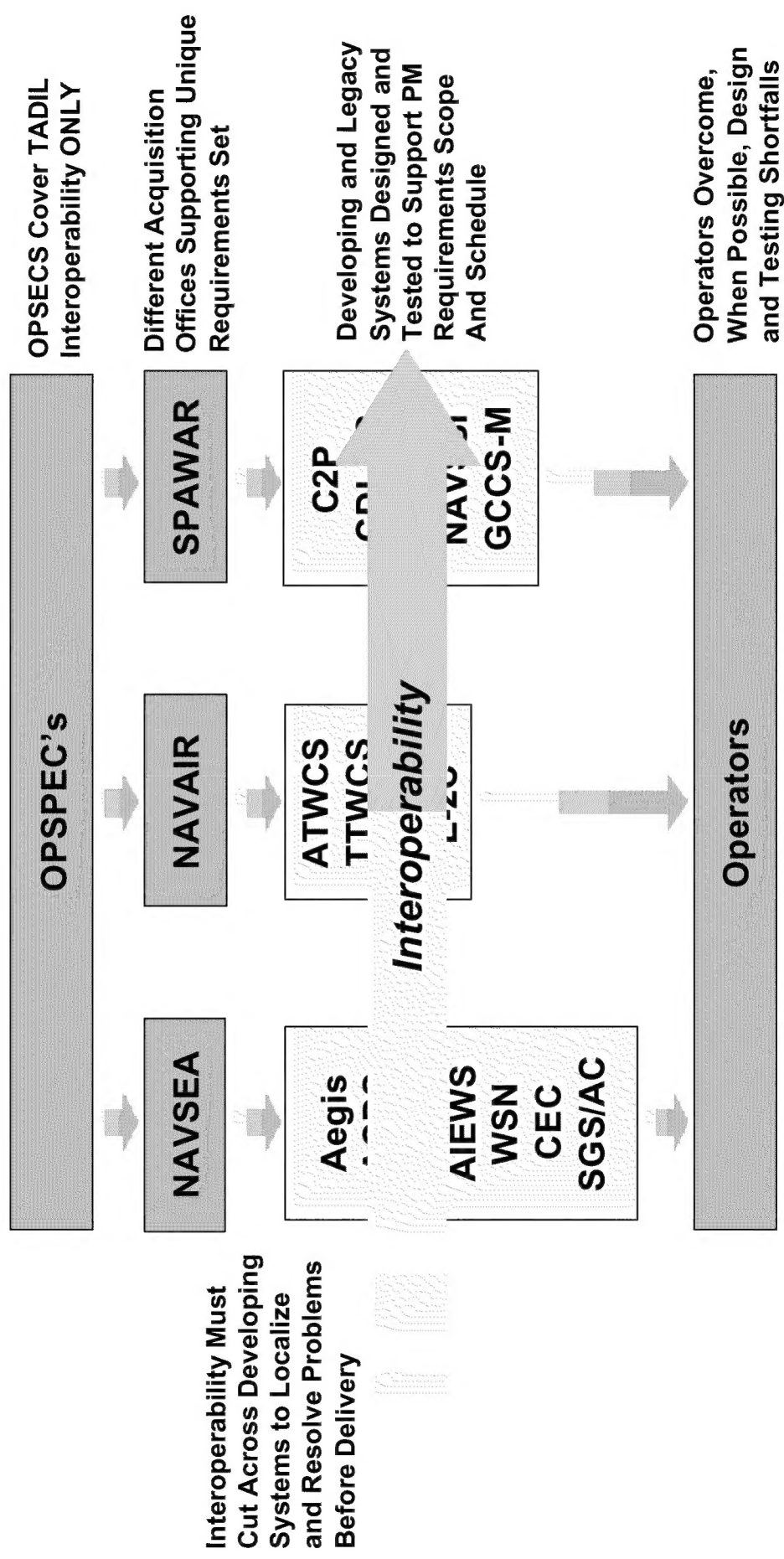
Supplementary Notes
Proceedings from Armaments for the Navy Interoperability Workshop, 30-31 May 2001 sponsored by NDIA.

Abstract

Subject Terms

Report Classification	Classification of this page
unclassified	unclassified

Classification of Abstract	Limitation of Abstract
unclassified	UU

Number of Pages
17

Outline

- **Aegis Combat System Engineering Agent (CSEA) View**

- **Aegis Baseline 6 III Interoperability Initiatives**

- **Lessons Learned and Shortfalls**

- **Summary**

Aegis CSEA View

OPSEC's

NAVSEA	NAVAIR	SPAWAR

OPSECS Cover TADIL Interoperability ONLY

Different Acquisition Offices Supporting Unique Requirements Set

Developing and Legacy Systems Designed and Tested to Support PM Requirements Scope And Schedule

Aegis

AIEWS
WSN
CEC
SGS/AC

ATWCS
TTWCS

C2P

NAV:
GCCS-M

Interoperability

Operators

Operators Overcome, When Possible, Design and Testing Shortfalls

Interoperability Must Cut Across Developing Systems to Localize and Resolve Problems Before Delivery

*System Development "Business As Usual" will Not Achieve Interoperability Improvement*

Background

- CEC OPEVAL events led to formation of an Interoperability Task Force Senior System Engineering Council

  - Tasked to resolve System problems, point solution for CEC OPEVAL

  - ITF Link/IID/Interoperability team investigated 166 problems and corrected 38 over 17 months

- Concurrently PMS 400B asked, How can we improve interoperability during development?

- Lockheed Martin developed new test initiative to identify and correct interoperability problems during Baseline 6 Phase III development

Interoperability Improvement Required Infrastructure and Process Changes, I.e. Not "Business As Usual"
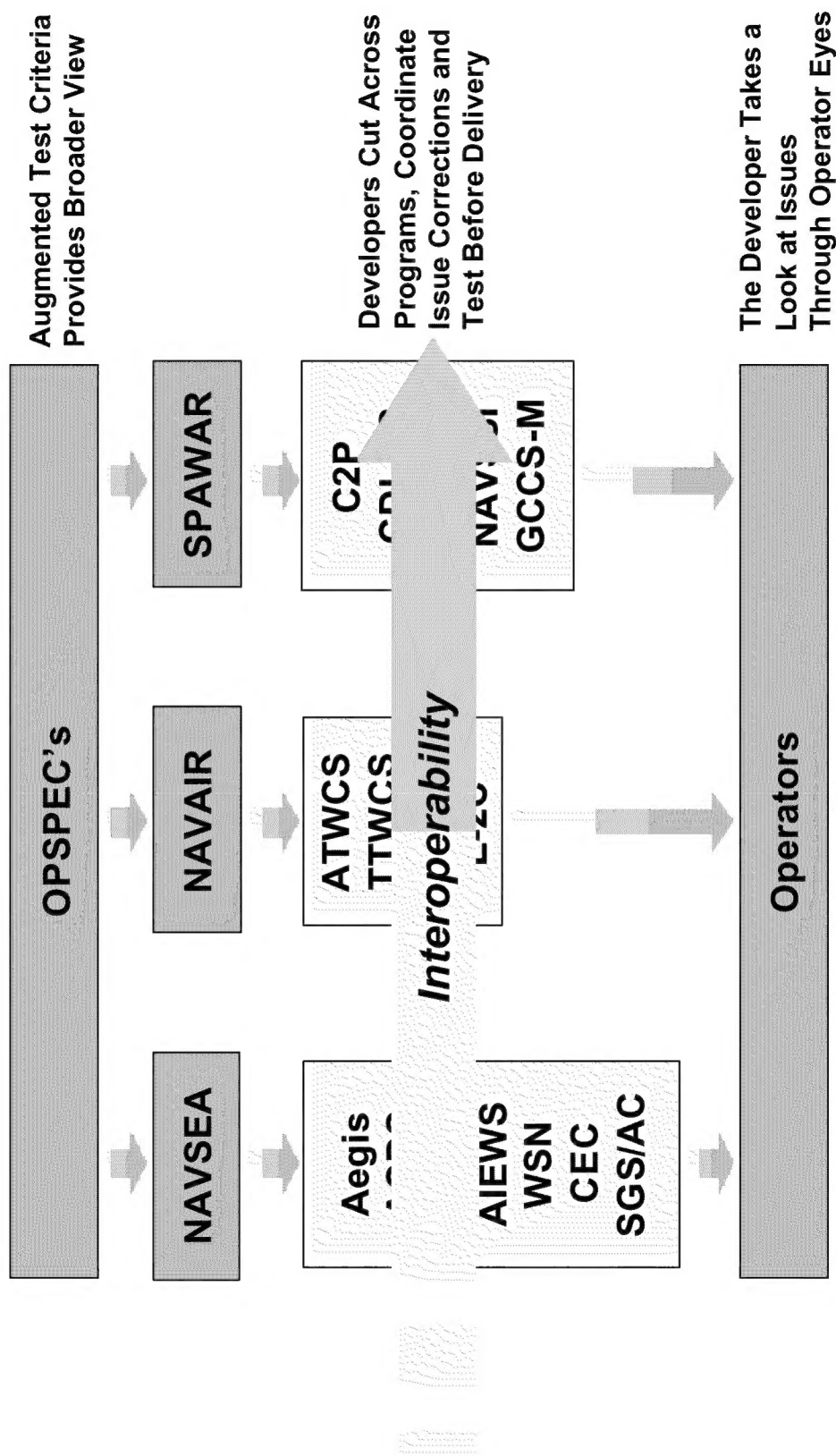
New Test Initiative – What to Do?
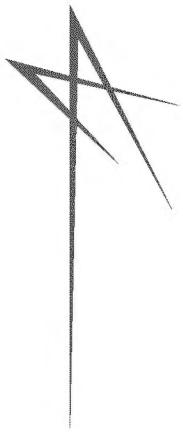
- **Develop a system test infrastructure that would stimulate multiple systems during development**
  - **An infrastructure that supported:**
    - □ *an ability to generate and distribute common dynamic tracks to be processed by multiple systems.*
    - □ *computer generated scenarios that would replicate operationally based experience.*

- **Develop a robust test criteria with quantitative performance measurements**

- **Develop test methodologies that facilitate:**
  - *Iterative cross system problem identification*
  - *Coordinated developer investigation*
 - *System wide problem resolution and validation*

Move Away From Sterile Single Ship Test Environments, Validating SIW Requirements…. Move towards Testing The Way The Ship Fights

New Test Initiative – How To Do It

OPSPEC's — Augmented Test Criteria Provides Broader View

NAVSEA	NAVAIR	SPAWAR

Developers Cut Across Programs, Coordinate Issue Corrections and Test Before Delivery

- Aegis
- AIEWS
- WSN
- CEC
- SGS/AC

- ATWCS
- TTWCS

- C2P
- NAV;
- GCCS-M

Interoperability

Operators — The Developer Takes a Look at Issues Through Operator Eyes

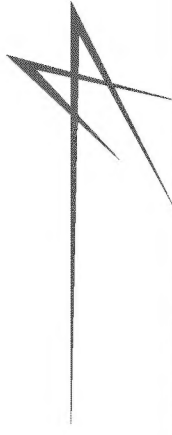*Interoperability Can Be Measured and Tested by Developers*

Multi-Aegis Combat System (MACS)
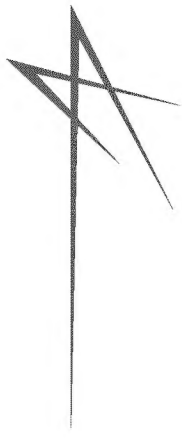
- *High-fidelity interoperability testing using operationally based scenarios on a distributed network*
  - *Distribute tracks via Distribute Interface Simulator (DIS)*
  - *Connect TADILS via Aegis Broadcast Network (ABN-16)*
  - *Connect CEC via secure LAN*

- *Supplements*
  - *Navy Link Certification*
  - *Link exercises with Patriot/THAAD,E-2, ACDS*

- *Provides*
  - *Common sensor environment*
    - *Multi-aircraft, Multi-TBM*
    - *Simultaneous AAW and TBM*
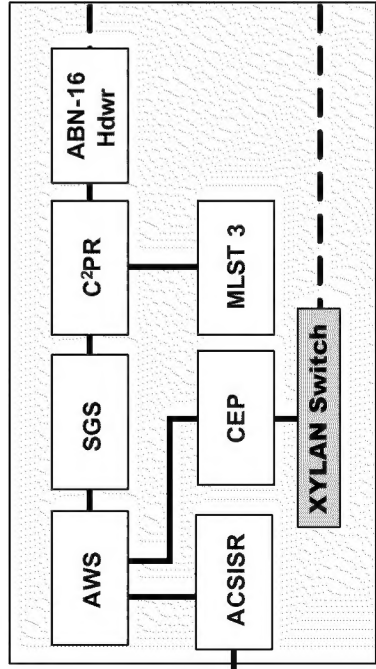
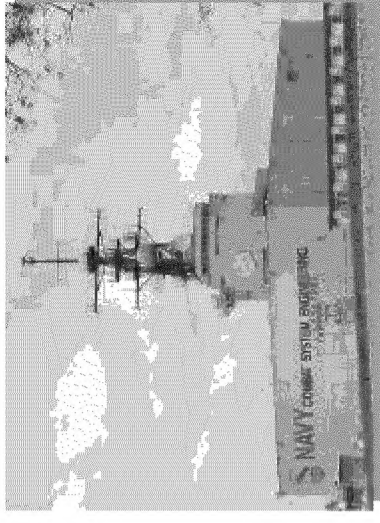*Built Battle Force Rancocas*

Battle Force Rancocas

CSEDS

3rd Deck

AWS — CEP — ACSISR

AWS — C²P — MLST 3

C²P — SGS / AC

C²P — ABN-16 Hdwr

WASP

XYLAN Switch

2nd Deck

CEP — AWS — ACSISR

MLST 3 — C²PR — SGS

C²PR — ABN-16 Hdwr

ABN-16

Direct Connect via NSCC F/O LAN

ACSIS DIS Network .47

PTC-2

C²PR — ABN-16 Hdwr

C²PR — MLST 3

SGS — C²PR

SGS — CEP

AWS — ACSISR

CEP

XYLAN Switch

XYLAN Switch
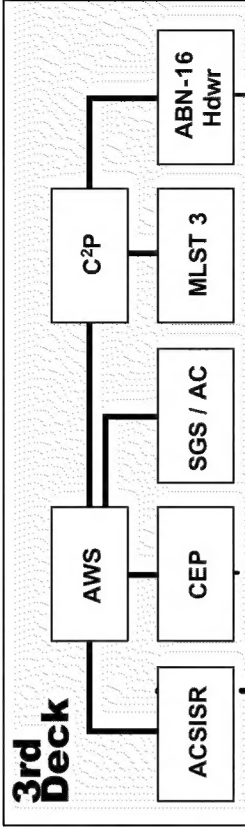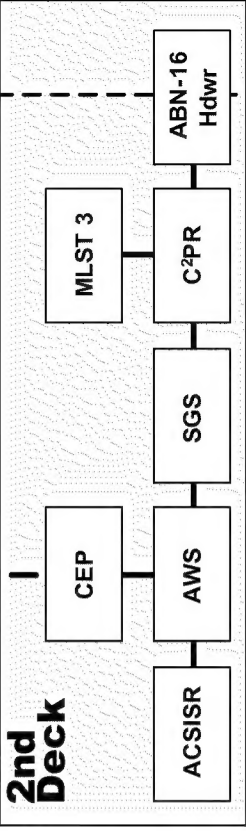
MACS Interoperability Test Goals
Temp 801 Based Criteria

Level Definition (Abridged)

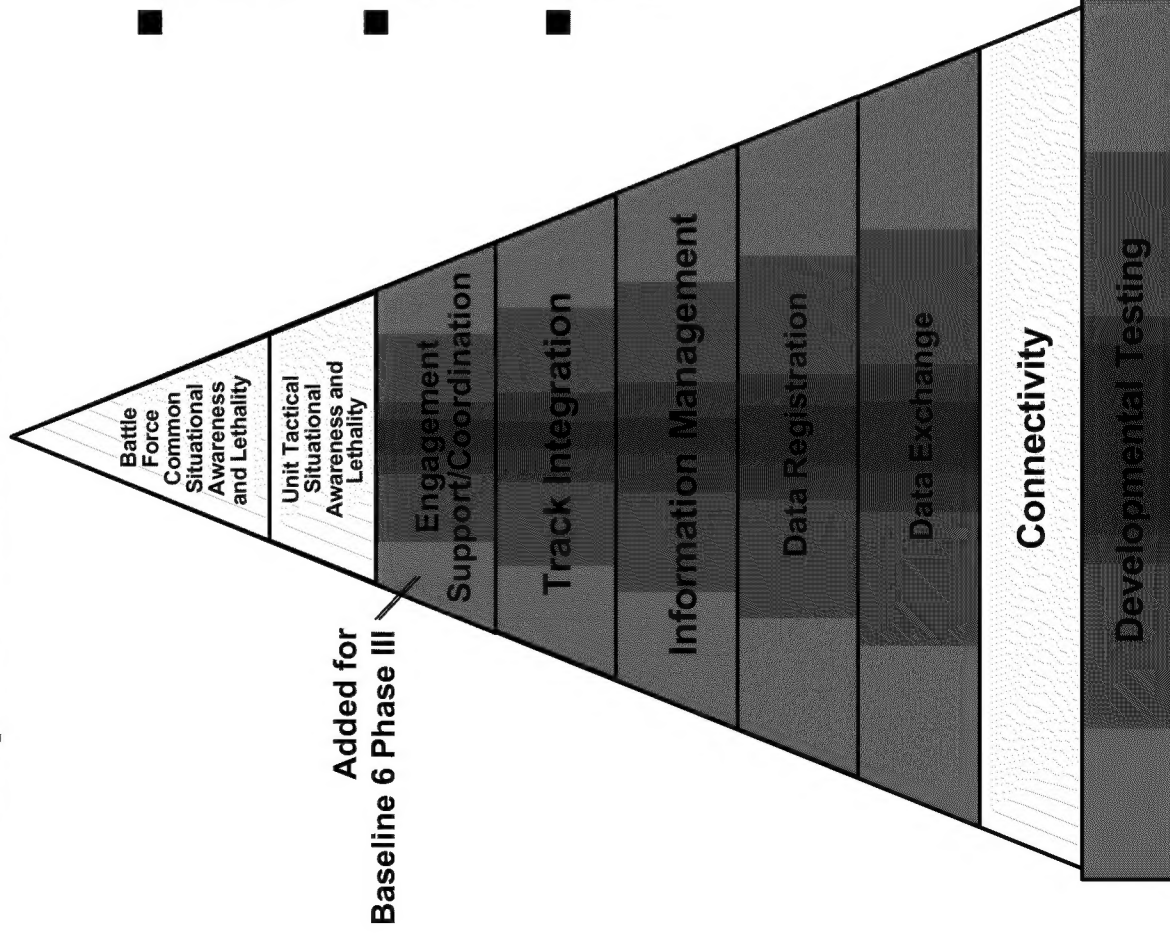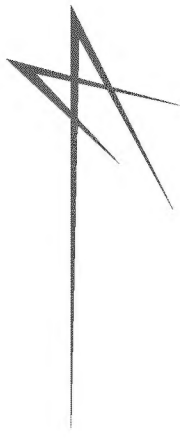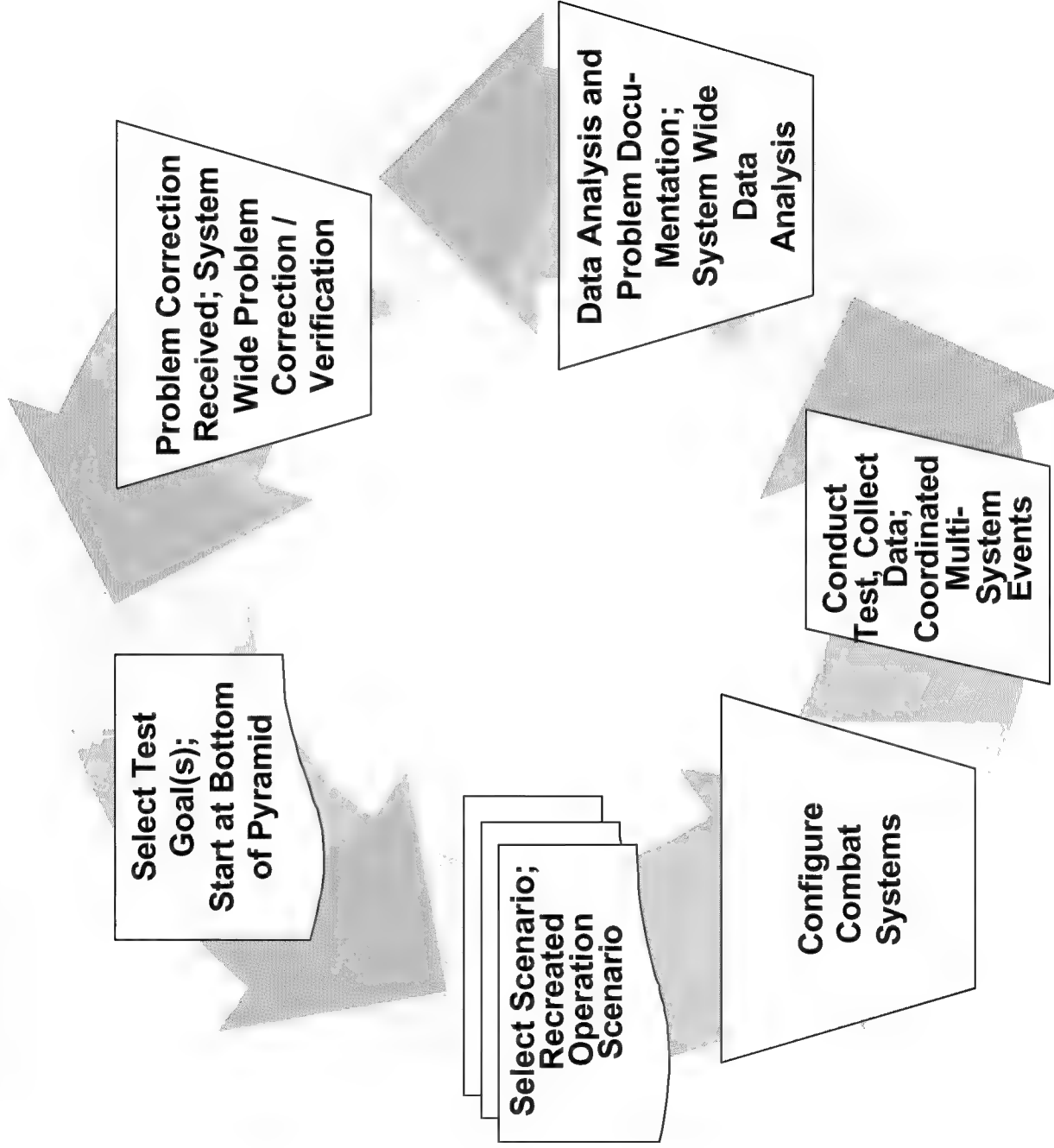- *Engagement Support/Coordination:* Exploitation of integrated tack data and connectivity to support and coordinate air/TBM engagements

- *Track Integration:* The fusion of local and remote sensor data and track parameters (correlation, decorrelation, mutual tracking)

- *Information Management:* The storage and management of local and remote track parameter data (ID, IFF, etc.)

- *Data Registration:* The corrective alignment of local and remote track position and kinematic data

- *Data Exchange:* The sharing of data at the element and unit level

- *Developmental Testing:* Verification of MACS test architecture and procedures

Added for
Baseline 6 Phase III

Battle Force Common Situational Awareness and Lethality

Unit Tactical Situational Awareness and Lethality

Engagement Support/Coordination

Track Integration

Information Management

Data Registration

Data Exchange

Connectivity

Developmental Testing

053001 / B / P-01-1652OPC-09

Test Process

Select Test Goal(s); Start at Bottom of Pyramid

Select Scenario; Recreated Operation Scenario

Configure Combat Systems

Conduct Test, Collect Data; Coordinated Multi-System Events

Data Analysis and Problem Docu-Mentation; System Wide Data Analysis

Problem Correction Received; System Wide Problem Correction / Verification

ACSIS Scenario Used for Data Registration Testing

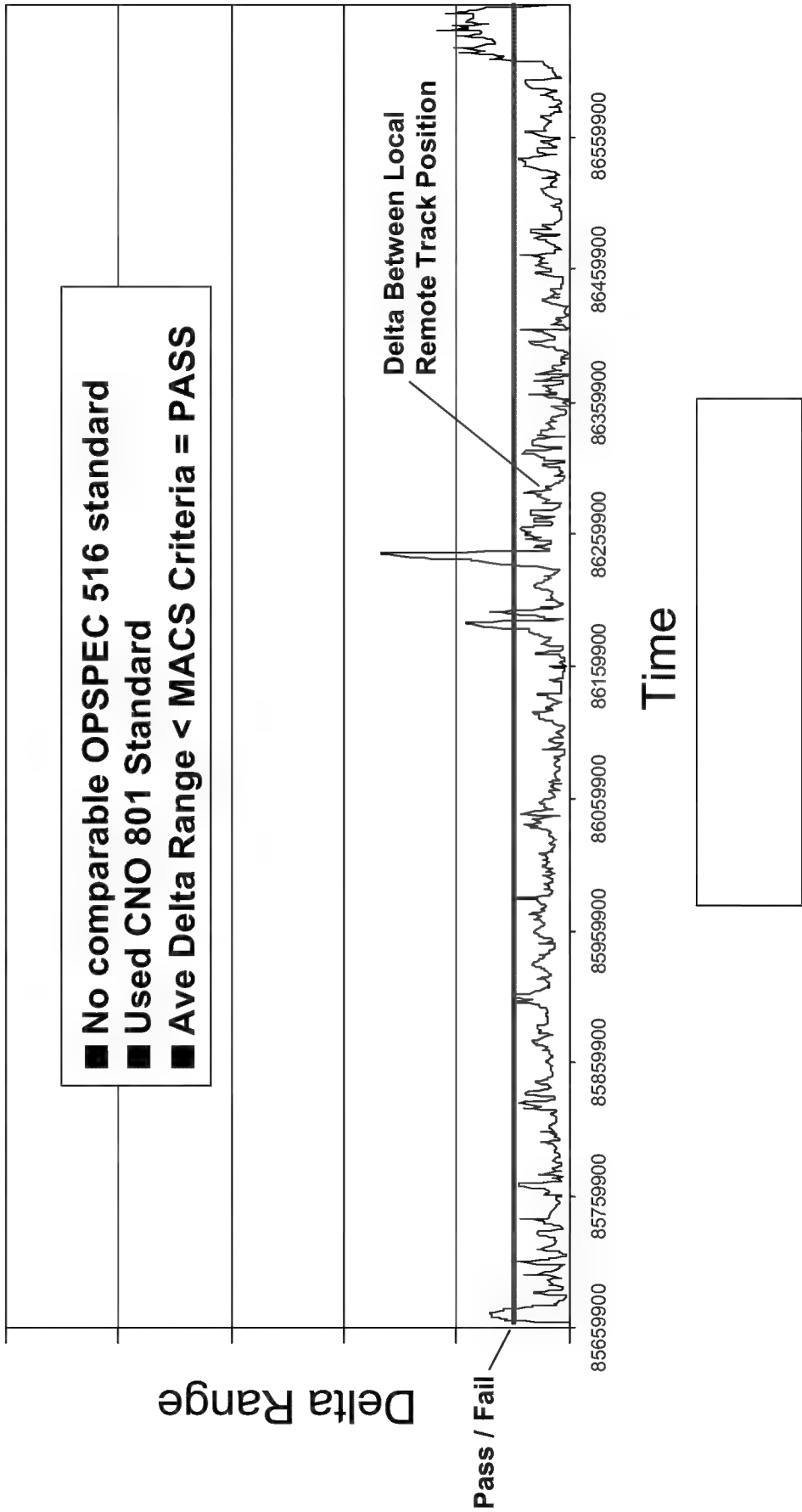| Scenario	Permutation	Section	Recommended script name
1. Baseline AAW	1. Single threat (bandit A)	A2.1.1.1	6P3_INT_BASE_AAW1
1. Baseline AAW	2. Single threat (bandit B)	A2.1.3.1	6P3_INT_BASE_AAW2
1. Baseline AAW	3. Dual threat (bandit A & B)	A2.1.3.2	6P3_INT_BASE_AAW3
2. Baseline AAW mode swap	1. Single threat (bandit A)	A2.2.1.1	6P3_INT_BASE2_AAW1
2. Baseline AAW mode swap	2. Single threat (bandit B)	A2.2.3.1	6P
2. Baseline AAW mode swap	3. Dual threat (bandit A & B)	A2.2.3.2	6P
3. Dual-Axis AAW threat	N/A	A2.3	6P
4. Modified Dual-Axis AAW threat	1. Single ASCM salvos	A2.4	6P
4. Modified Dual-Axis AAW threat	2. Two ASCM salvos	A2.4	6P
4. Modified Dual-Axis AAW threat	3. Three ASCM salvos	A2.4	6P
4. Modified Dual-Axis AAW threat	4. Four ASCM salvos	A2.4	6P
5. Baseline HVA AAW	1. Two ASCM salvos	A2.5	6P
5. Baseline HVA AAW	2. Four ASCM salvos	A2.5	6P
5. Baseline HVA AAW	3. Six ASCM salvos	A2.5	6P
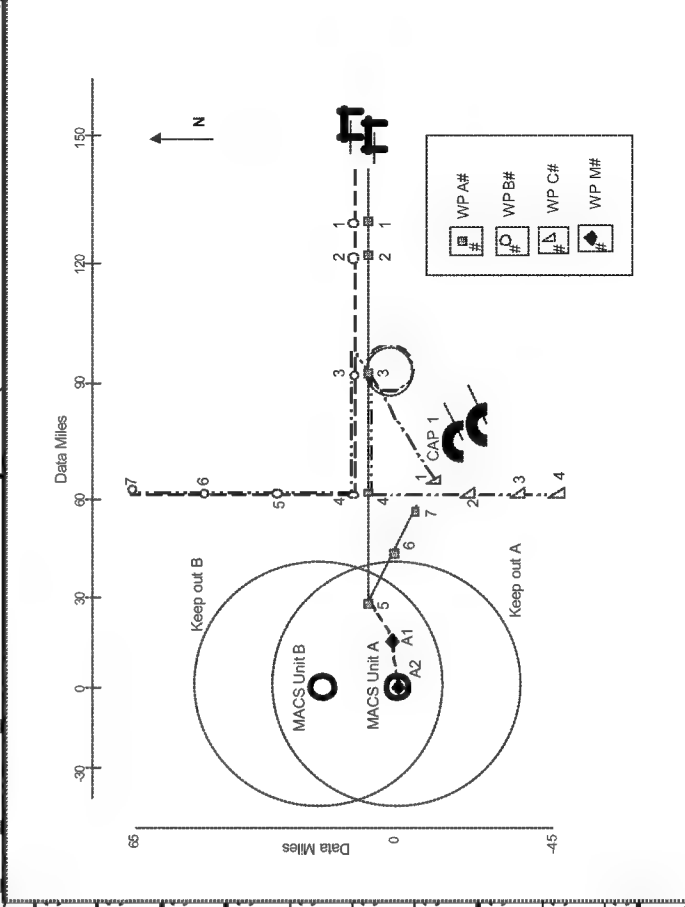
Data Registration Testing:

An Example
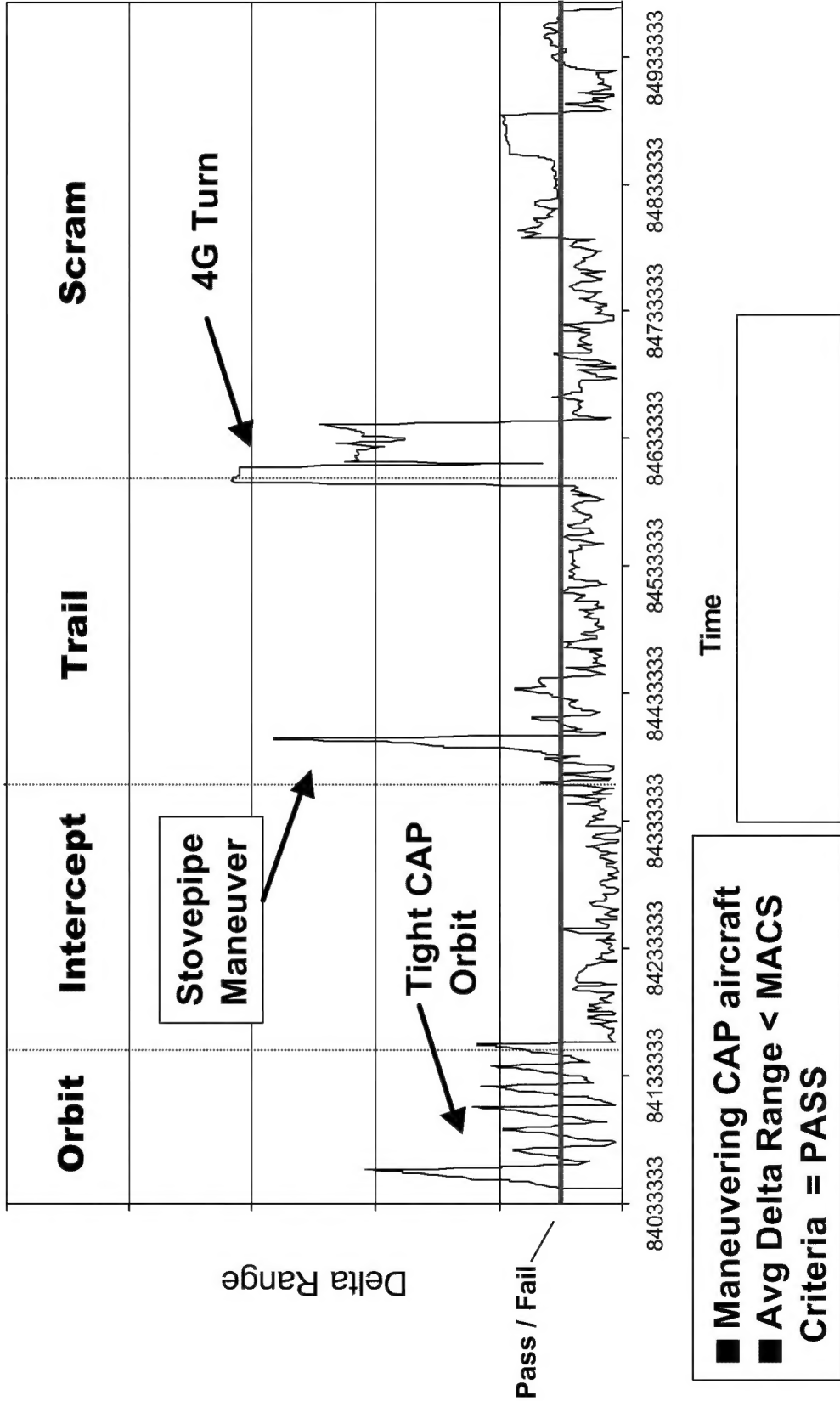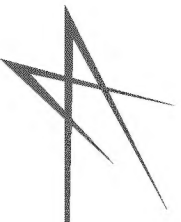
- MACS test matrix identifies 11 priority link specific data registration test goals and pass / fail criteria for:
  - Relative Gridlock
  - IU Registration
  - Sensor Registration
  - Developed ACSIS DIS scenario to inject sensor error that requires compensation using data registration

- Initial results
  - **Failed on visual inspection:** *Tracks jumped wildly while conducting relative gridlock throughout scenario*
  - Data analysis identified C2PR N-1-3033, SGS / AC Sensor Registration application and C&D program problems
  - All fixes verified
  - Basic Relative Gridlock, IU Registration, and Sensor Registration functionality passed

Success Story, But Required Five Month Iterative Process

Relative Gridlock Test Result:
Aegis-Aegis Mutual Track

■ No comparable OPSPEC 516 standard
■ Used CNO 801 Standard
■ Ave Delta Range < MACS Criteria = PASS

Delta Between Local Remote Track Position

Delta Range

Pass / Fail

Time

85659900 85759900 85859900 85959900 86059900 86159900 86259900 86359900 86459900 86559900

Sensor and IU Registration Results

Orbit | Intercept | Trail | Scram

Stovepipe Maneuver

Tight CAP Orbit

4G Turn

Delta Range

Pass / Fail

Time

84033333 84133333 84233333 84333333 84433333 84533333 84633333 84733333 84833333 84933333

■ Maneuvering CAP aircraft
■ Avg Delta Range < MACS
   Criteria = PASS

Sensor and IU Registration Limitations

Legend:
- Plot for CAP aircraft engaged in a Furball
- Ave Delta Range > MACS Criteria = Fail
- Likely reflects Link 16 update rate limitations
- Despite limitations, overall link data registration performance assessed to be nominal

Y-axis: Delta Range

Pass / Fail

X-axis: Time

85712410, 85762410, 85812410, 85862410, 85912410, 85962410, 86012410, 86062410, 86112410

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MACS Lessons Learned
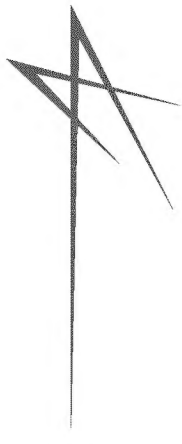
- *Developmental testing should be conducted in small doses with limited objectives*

- *Test configuration very challenging*
  - *Most resource intensive test configuration we employ*
  - *Developmental testing demands large test time investment per test objective*

- *Test architecture needed thorough testing and debugging*

- *Testing generates heavy data analysis demands*

- *DIS essential for TBMD interoperability testing*

Finding and Fixing Interoperability Problems is an Iterative Time Consuming Process

Summary

- *Lockheed Martin NE&SS-Surface Systems initiated MACS testing in response to PMS 400B direction to "improve interoperability"*

- *Infrastructure developed and testing in progress*

- *Experienced growing pains*

- *Testing has exposed problems that otherwise would be difficult to find or collect data on*

- *The use of DIS architecture has proven a necessity for TBMD interoperability testing*

- *Test shortfalls that affect ability to find and quickly resolve problems*
  - *Architecture / equipment*
  - *Analysis tools*
  - *Availability / participation of all elements developers*

Interoperability is Not a Goal, It's a Process